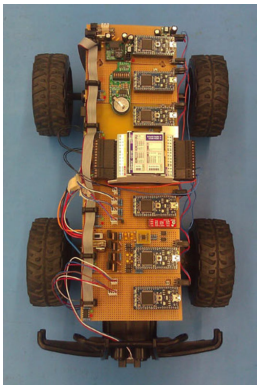
E-Kart with seven CANopen nodes

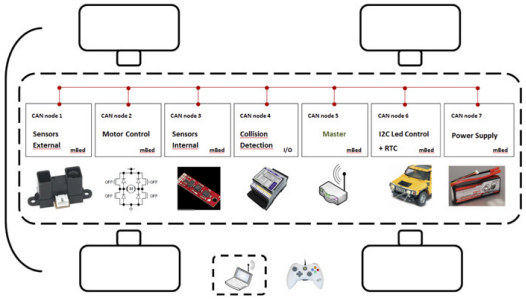
At the KU Leuven university (Belgium), Prof. Dr. Jeroen Boydens and his team have developed an E-Kart control system based on CANopen. For the CANopen software, the open source CanFestival protocol stack was chosen.



The R/F car is controlled by a CANopen network embedded in the vehicle (Photos: Boydens)

FOR THE APS4ES RESEARCH PROJECT, CANopen has been selected as communication system to interconnect the seven nodes in the vehicle. The aim of the project was to explore by “Co-design & Co-verification” what can be improved when hardware and software designers work together on the same project. During the elaboration phase of the project, a couple of practical applications of embedded systems were realized, with all necessary attention towards documentation and quality assurance. Finally, the concrete applications and manuals formed the base for the support and development of seminar materials for the professional bachelor seminars of Electronic-ICT and Electromechanics-Automation studies.

As a functional E-Kart was not immediately available, first a demo application was created. An R/F-car was converted in such a way that it is equipped with seven CAN-nodes. Each CAN-node has a separate function. The figure below shows the schematic overview of the integrated CAN-nodes. The table below that provides a list of implemented functionalities on each CAN-node.



R/F car with seven CANopen nodes (Source: Boydens)

Implemented functions

Node	Function
1	Distance measurement Infrared and Ultrasonic
2	Two control H-bridges for the front and rear motor
3	I/O module connecting two temperature sensors for the temperature of the ambient air and the

	temperature of the rear motor; one detection angle position sensor for the front wheels; one speed measurement unit for the rear motor with infrared and hall sensor; one sensor stick with accelerometer, gyroscope, and magnetic compass
4	Industrial CANopen I/O module connected with obstacle detection units for front and rear
5	NMT master module via Ethernet connected with wireless router and laptop
6	RTC and LED lighting connected by I^2C-bus
7	Power module that converts battery tension in the desired 5-V_{DC} and 12-V_{DC} battery tension control

The researchers selected the CanFestival protocol stack, an open-source software. The protocol software supports the CANopen I/O profile as specified in CiA 401. As hardware platform, the Mbed module was chosen. This module is a prototype board with an LPC1768 Cortex-M3 processor. The Mbed compiler provides a pre-configured online C/C++ integrated development environment (IDE) to write programs and compile and download them to run on the Mbed's ARM processor. It also provides a library, which covers many peripherals and allows accessing the components at a high abstraction level.

The R/F-car CANopen network was connected with the PC by means of the CAN/USB dongle from Lawicel (Sweden). The USB port can be treated by software as a standard COM port. With the dongle there is also a DLL available, which can be integrated in the PC software in order to send commands directly from the PC to the CANopen nodes. Sensor data from the sensors on board of the R/F-car can also be shown on the PC screen. The PC software was created with IDE 2010 visual studio and C++.

"The flexibility of the Mbed prototype board makes it easy for students to develop an embedded application themselves," explained Prof. Boydens. "It is not required to delve into register settings to make a functional program." He added: "Although CAN and CANopen have existed for many years, their potential is still not well known. It is a flexible way to connect several electronic modules together and provide a high reliability communication system at the same time. Also, standard I/O modules can be easily integrated in the same project."

Currently, there are three karts realized. One has been transformed as a functional E-Kart. The mechanical implementation of the CANopen nodes on the E-Kart still remains to be executed. Two other Karts still have to be completed. Other hardware/software platforms will be evaluated as an alternative replacement for the Mbed prototype board, for instance LPCXpresso1769 by Embedded Artists (Sweden).